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Visualization of Research Data Management: A Scientometric Analysis

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Abstract

Research data management has a significant value in this current scenario for the rapid development of information society. This research presents current trends in global research data management, identification of the most relevant topics through the thematic map, mapping of authorship, co-occurrences, review of bibliometric laws, citation analysis, keyword growth analysis and some more related issues. The purpose of this paper is to analyze the scientometric and bibliometrics of research data management to highlight the importance of its use in the research field. This paper aims to know the current global situation of research data management advancement keeping abreast of latest data sources for upload and preservation of plenty of research data generated daily. A data search was conducted from the most comprehensive database- Scopus based on relevant keywords in research data management. Extracted data was filtered by year, document type, language, and publication level then final purified data were analyzed and visualized by BibliometrixR, VOSviewer, MS Excel, and Datawrapper. A total of 1720 publications were retrieved from Scopus after an initial keyword search, and 1273 publications were selected applying limited exclusion criteria. The data contained 780 articles, 05 books, 57 book chapters, 372 conference papers, and 59 reviews. Most publications in research data management are in 2022 (n=180), most papers from source "Data Science Journal" (n=57), and most papers published by author "Ribeiro, C" (n=15).

Keywords: Research Data, Research Data Management, RDM, Visualization, Bibliometrics, Scientometrics, BibliometrixR.

1. Introduction

In this educational society, data is the mother source of all kinds of research where the main task is to manage data in a systematic way for the development of the world. Data should be properly organized or managed when used in research to help find someone who needs it later or an organization needs it. So, without real and relevant data, which is available on data-sharing sites,

research cannot take place at present (Patel, 2016). Therefore, this study is motivated by the growing need to understand how research data management (RDM) is being handled across disciplines, institutions, and geographies. Data is analyzed or evaluated with the help of recent trends to help the researcher do efficient work. Visualization tools and analysis software make this task largely possible (Wijk, 2005). The concept of visualization in research deals with the graphical and pictorial display of data analysis. Tabulated data is basically

shown by visualization tools with many creative ways to make research easier to understand. For example, in this paper data visualization tools BibliometrixR, Datawrapper, VOSviewer and MS-Excel are used for data analysis with graphical and pictorial views. Furthermore, many visualization tools are used as data analysis tools (such as Tableau, Looker, Domo, WhataGraph, MS-Power BI, etc.) (GeeksforGeeks, 2024) with graphical views of various aspects. Hence, applications of visualization tools are best suited for various departments (such as health, ENVIS, libraries and more) to graphically visualize complex data (Sadiku, Matthew N. O. et al., 2016).

The main objective of this study is to explore global trends, thematic developments, and key contributors in the domain of RDM using scientometric techniques. RDM is commonly used in data science to store, organize, and share research data globally. Therefore, the main points of RDM are data storage, data management, maintaining quality, sharing data in a proper way

to follow the ‘Data Act’ and finally a proper documentation of data that can be systematically accessible to anyone (University of Reading, n.d.). Data is the capital of any research process that takes research to the top level of evidence-based impact to improve society. A well-maintained database always has an impact on the user’s ability to use quality time for his research. Research data management does a good job of preventing and preserving authentic data for users to understand for long-term benefits. This technologically advanced society generates large amounts of data with many creative ideas every day, so a “FAIR (Searchable, Accessible, Interoperable and Reusable)” research will be a must through RDM. Research data management system works on a lot of research data to be openly accessed and follows some points such as easy to find, easy to analyze, ensure data loss, get credit etc. which are beneficial for a researcher (Longwood Research Data Management, n.d.).

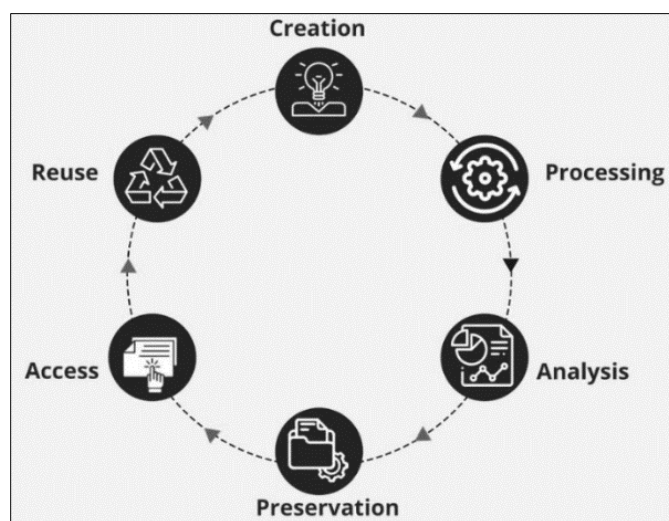


Figure 1 Research data cycle (Ball, 2012)

2. Review of literature

Cox & Pinfield (2014) in their paper trace the use of RDM in UK university libraries up to 2012. They broadly discuss advisory principles and recent data management services in their paper. They also find some challenges in the impact of RDM related to cost, capacity criteria etc. **Patel (2016)** in his paper shows research data management framework with benefits of sharing aspects. He also discusses research data management issues and barriers to moving research forward. At an institutional level he presented the workflow of “National Repository of Open Research Data” in his paper. **Yun & Schultz (2017)** produced an article on RDM services in US academic libraries. They examined hundreds of organizations’ websites to analyze data management contents through statistical software’s (“SPSS23” etc.). **Ashiq, Usmani & Naeem (2020)** traditionally discuss the literature on research data management (RDM) in their paper. They searched relevant literature from various databases and analyzed with “PRISMA” guidelines. **Heuer (2020)** in his paper mainly discusses basic concepts of research data management including scope, data sharing platform, limitations, “FAIR research data” etc. A paper by **Birkbeck, Angle & Samman (2022)** thoroughly discusses the limitations of RDM practice. Mainly they clearly point out the challenges of RDM with data security and storage, right way resource management, attitudes towards data sharing, data privacy of authorities and funding issues. An overview of visualization is discussed in a paper by **Schroeder & Martin (2004)**, **Manovich (2010)**. They both show the basic features of visualization along with some algorithms, facilities, examples etc. **Jalal (2018)** in his paper analyzed a specific topic using VOSviewer to visualize data more efficiently. He used various features of this tool along with some mathematical calculations to visualize the research output. **Wijk (n.d.)** discusses the importance of visualization in the ICT era to better analyze

information. In his paper, he has analyzed in detail visualization by different models and methods with the implications in technology, art and science. **Arendt et al. (2014)** mentioned and discussed a software “e!DAL” for publishing and sharing research data in their paper. They have excellently reviewed the design and implementation of this software along with version management, metadata, data publishing, data security etc. **Amorim (2017)** in his paper shows a comparative study of different RDM platforms. He has comparative analysis with several features for selected platforms namely ‘DSpace,’ ‘CKAN,’ ‘Figshare,’ ‘Zenodo,’ ‘ePrints’ and ‘EUDAT.’ **Koltay (2017)** analyzes literacy on research data by those who provide and manage the data in his article. He highlights the behavior of researchers with the issues of data citation, quality, and data literacy among librarians. **Bouchrika (2024)** describes research data management in the context of 2024 with benefits of RDM, data management planning and other key insights of RDM in his blog.

3. Objectives of the study

- i. To study how the number of research papers on Research Data Management has grown over the years;
- ii. To find out the top 20 sources and authors who have published the most papers in this field;
- iii. To check author productivity using Lotka’s Law;
- iv. To identify the top 10 most used keywords by authors and show their growth;
- v. To show how different authors are connected using a Sankey diagram;
- vi. To analyze which keywords often appear together in research papers using a co-occurrence network;
- vii. To explore the main themes in Research Data Management research using thematic map.

4. Methodology

4.1 Search Strategy

The Scopus database was systematically used for data retrieval on May 29, 2024. After the literature review, the selected author keywords related to research data management became the keyword search (AUTHKEY) in the database. After obtaining the initial total publications (n=1720) the data were filtered by four criteria; Year: 1994-2023, Language: English, Publication Stage: Final, and Document Type: Article, Conference Paper, Review, Book Chapter, Book. Total data (n=1273) were retrieved after filtering and imported into CSV, BibText, and RIS formats.

4.2 Data collection and analysis

Retrieved bibliographic data were imported into Biblioshiny using BibliometrixR (ver. 4.4.0) and

RStudio (ver. 2024.04.2-764) for data analysis. Using this tool, data were analyzed by various aspects of research data management such as; Annual Publication Growth, Author Productivity by Lotkas Law, Sankey Diagram, Top 20 Sources, Top 20 Authors, Top 10 Author Keywords, and Thematic Map Analysis. Another data analysis tool VOSviewer (ver. 1.6.20) is used to visualize these two aspects of research data management i.e. Co-occurrence with author keywords and Co-authorship. The studied data were sorted using MS-Excel based on the total number of publications for the top 20 authors and scientific productions in the field of research data management. Another online tool Datawrapper (<https://www.datawrapper.de/>) and ChatGPT (<https://chatgpt.com/>) were used to generate charts and graphs for annual publications and top 10 author keywords on this topic.

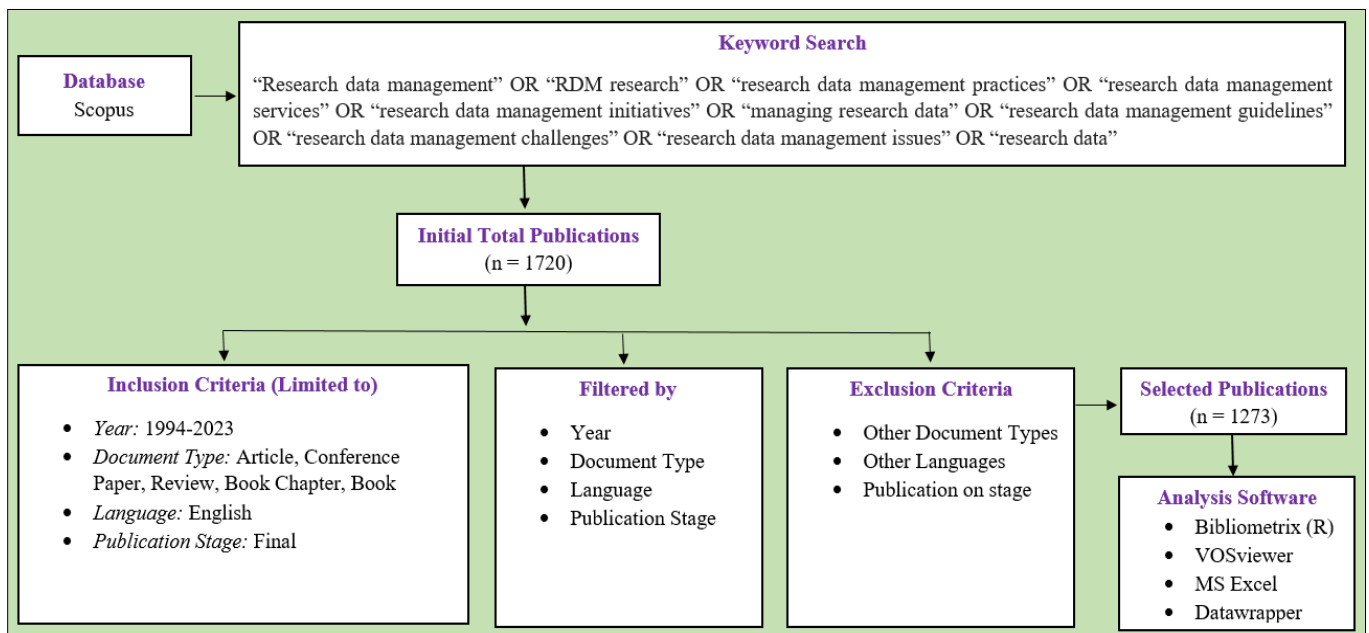


Figure 2 Steps of search strategy on research data management

Year	Articles	Year	Articles
1994	1	2009	18
1995	0	2010	10
1996	0	2011	8
1997	1	2012	33
1998	0	2013	40
1999	1	2014	66
2000	1	2015	54
2001	4	2016	82
2002	0	2017	98
2003	0	2018	100
2004	2	2019	131
2005	1	2020	135
2006	2	2021	131
2007	6	2022	180
2008	8	2023	160

Table 1 Year-wise publications

5. Findings of the study

This study provides basic bibliometric information after filtering from the initially retrieved data on

research data management– Total sources (journals, books, etc.) are 535, total documents 1273, annual growth rate (%) is 19.13, average document age is 5.55, average citations per document is 8.439 and references are 33358.

5.1 Year-wise growth of publications

Literature was retrieved for a period of 30 years (1994-2023) on research data management publications in the Scopus database mentioned in the methodology. According to this data, Figure-3 and Table-1 shows the growth of publications, where the graph has increased since 2012 and the highest peak (n=180) is the year 2022.

5.2 Top 20 Scientific production & sources

Table 2 shows the top 20 scientific productions and sources in research data management based on the total number of publications/papers. This table includes the total number of papers published, total citations, impact score (2022-2023), and publisher details. “Data Science Journal” has the highest number (n=57) of publications with a total of 547 citations, an impact score of 2.78, and the publisher is Ubiquity Press.

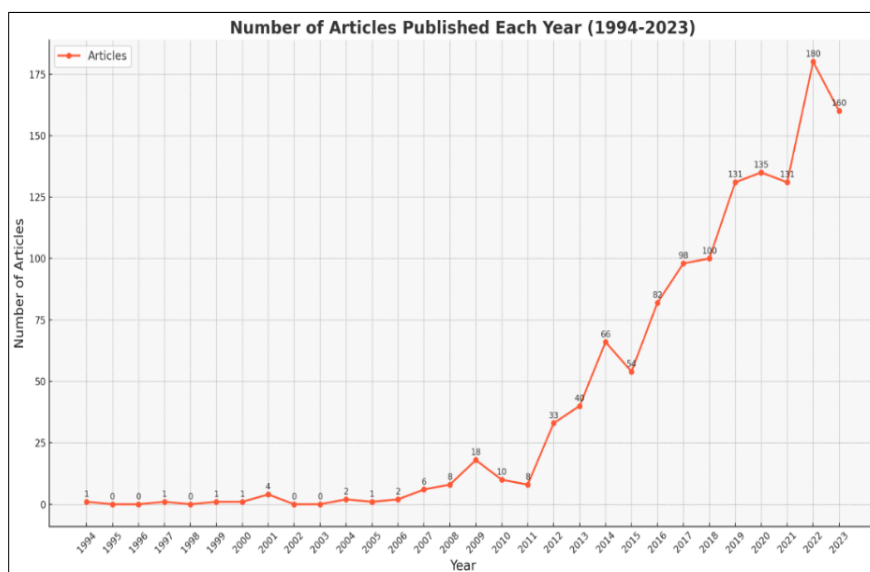


Figure 3 Graphical view of year-wise pub. in RDM

Rank	Source	Publisher	No. of Papers		Impact Score
1	Data Science Journal	Ubiquity Press	57	547	2.78
2	Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	Springer Verlag	56	211	1.27
3	CEUR Workshop Proceedings	Springer	36	67	0.39
4	Communications in Computer and Information Science	Springer Science and Business Media Deutschland GmbH	34	134	0.53
5	Proceedings of The Association for Information Science and Technology	John Wiley & Sons Inc.	32	111	0.98
6	Nature	Nature Publishing Group	27	796	23.95
7	ACM International Conference Proceeding Series	Association for Computing Machinery (ACM)	21	55	0.5
8	Procedia Computer Science	Elsevier BV	20	143	2.56
9	LIBER Quarterly	The Association of European Research Libraries	17	221	1.1
10	Journal of Academic Librarianship	Elsevier BV	16	149	3.18
11	Library Philosophy and Practice	The University Libraries of the University of Nebraska	16	33	0.64
12	Proceedings of the ACM/IEEE Joint Conference on Digital Libraries	Association for Computing Machinery	15	95	××
13	DESIDOC Journal of Library and Information Technology	Defence Scientific Information & Documentation Centre (DESIDOC)	12	106	0.97
14	Lecture Notes in Informatics (LNI), Proceedings - Series of The Gesellschaft Fur Informatik (GI)	Gesellschaft fur Informatik (GI)	12	18	0.26
15	IFLA Journal	SAGE Publications Ltd	11	248	1.65
16	Journal of Documentation	Emerald Group Publishing Ltd.	10	201	2.97
17	Journal of Librarianship and Information Science	SAGE Publications Ltd	10	383	2.64
18	Studies in Health Technology and Informatics	IOS Press BV	10	35	0.73
19	Proceedings of The Asist Annual Meeting	American Society for Information Science	10	41	
20	Proceedings of The International Conference on Dublin Core and Metadata Applications	Dublin Core Metadata Initiative and National Library Board Singapore	10	37	0.23

Table 2 Top 20 Scientific productions based on number of papers

5.3 Top 20 Authors and publications

The study includes Scopus data on a total of 3760 authors and 215 authors of single-authored documents. The top 20 authors are highlighted in Table-3 is based on the maximum number of

papers published with total citations, h-index, g-index, and affiliation. Highest number of papers is published in RDM by “Ribeiro, C” with 15 publications, 55 citations, 5 h-index and 6 g-index from Universidade do Porto, Portugal.

Ran k	Author	Affiliation	No. of Papers	Total Citations	h_index	g_index
1	Ribeiro, C	Universidade do Porto, Portugal	15	55	5	6
2	Schöpfel, J	GERIICO Laboratory, France	13	50	4	7
3	Da Silva, J R	Universidade do Porto, Portugal	11	39	4	5
4	Koepler, O	Technische Informationsbibliothek (TIB), Germany	10	81	5	8
5	Castro, J A	Institute for Systems and Computer Engineering, Technology and Science, Portugal	9	39	4	6
6	Rodrigues, J	Universidade do Porto, Portugal	9	16	3	3
7	Koltay, T	Eszterházy Károly Catholic University, Hungary	8	253	7	8
8	Jeng, W	National Taiwan University, Taiwan	8	56	4	7
9	Kim, J	Ewha Womans University, South Korea	8	51	4	7
10	Kim, S	Jeonbuk National University, South Korea	8	32	4	5
11	Azeroual, O	German Centre for Higher Education Research and Science Studies (DZHW), Germany	8	29	3	5
12	Schimmler, S	Fraunhofer Institute for Open Communication Systems (FOKUS), Germany	8	60	3	7
13	Auer, S	Technische Informationsbibliothek (TIB), Germany	8	13	2	3
14	Schembera, B	Universität Stuttgart, Germany	7	81	6	7
15	Allard, S	University of Tennessee, United States	7	182	4	7
16	Tochtermann, K	Leibniz-Informationszentrum Wirtschaft, Germany	7	18	3	4
17	Cox, A M	The University of Sheffield, UK	6	361	6	6
18	Schreck, T	Technische Universität Graz, Austria	6	92	5	6
19	Tenopir, C	The University of Tennessee, United States	6	182	4	6
20	Cimiano, P	Universität Bielefeld, Germany	6	23	3	4

Table 3 Top 20 Authors & publications based on total no. of papers published

5.4 Lotka's Law analysis

Lotka's law deals with author productivity in the field of "research data management." Figure 4 and Table 4 shows the three criteria for author productivity which are documents written, number of authors, and proportions of authors (i.e. up to 5 documents are written by 23 authors so on).

Documents written	No. of Authors	Proportion of Authors
1	3155	0.834
2	399	0.105
3	134	0.035
4	41	0.011
5	23	0.006
6	14	0.004
7	3	0.001
8	7	0.002
9	2	0.001
10	1	0.000
11	1	0.000
13	1	0.000
15	1	0.000

Table 4 Author's productivity

5.5 Top 10 Author keywords

Figure 5 and Table 5 indicate the most used author keywords related to research data management. Here are the top 10 author keywords shown in the table and graph, "research data management" was appeared the most times (n=2512) in RDM analysis.

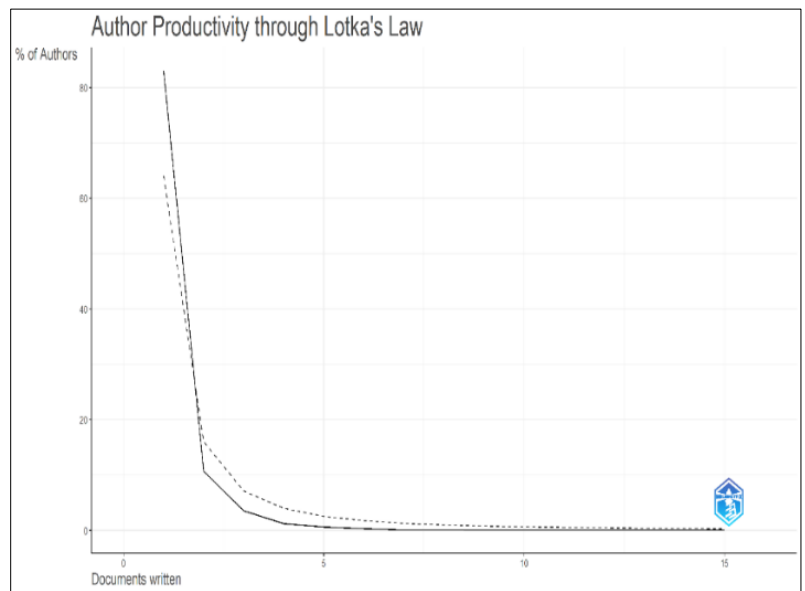


Figure 4 Graphical view of Lotka's law

Rank	Words	Frequency (n)
1	Research Data Management	2512
2	Research Data	2442
3	Open Science	464
4	Data Sharing	584
5	Metadata	406
6	Data Management	434
7	Open Data	388
8	Open Access	430
9	Academic Libraries	281
10	Data Curation	328

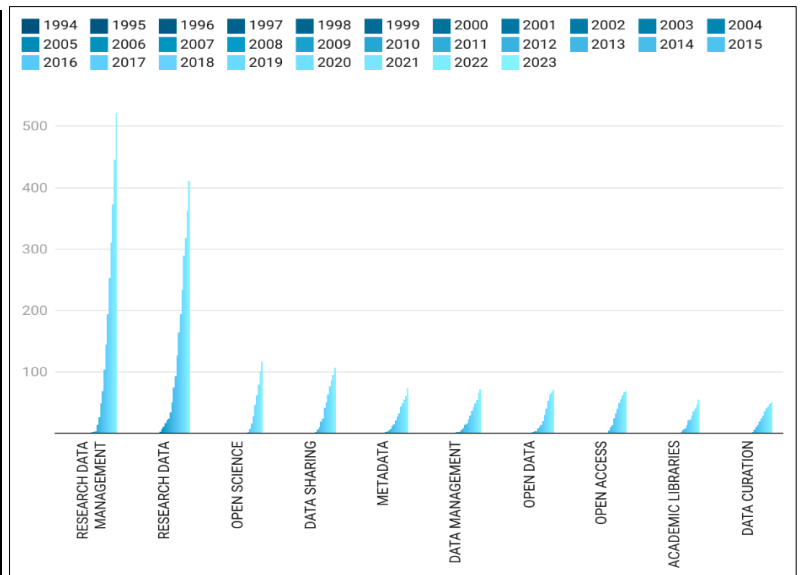


Table 5 & Figure 5 Top 10 author keywords in RDM with graphical view

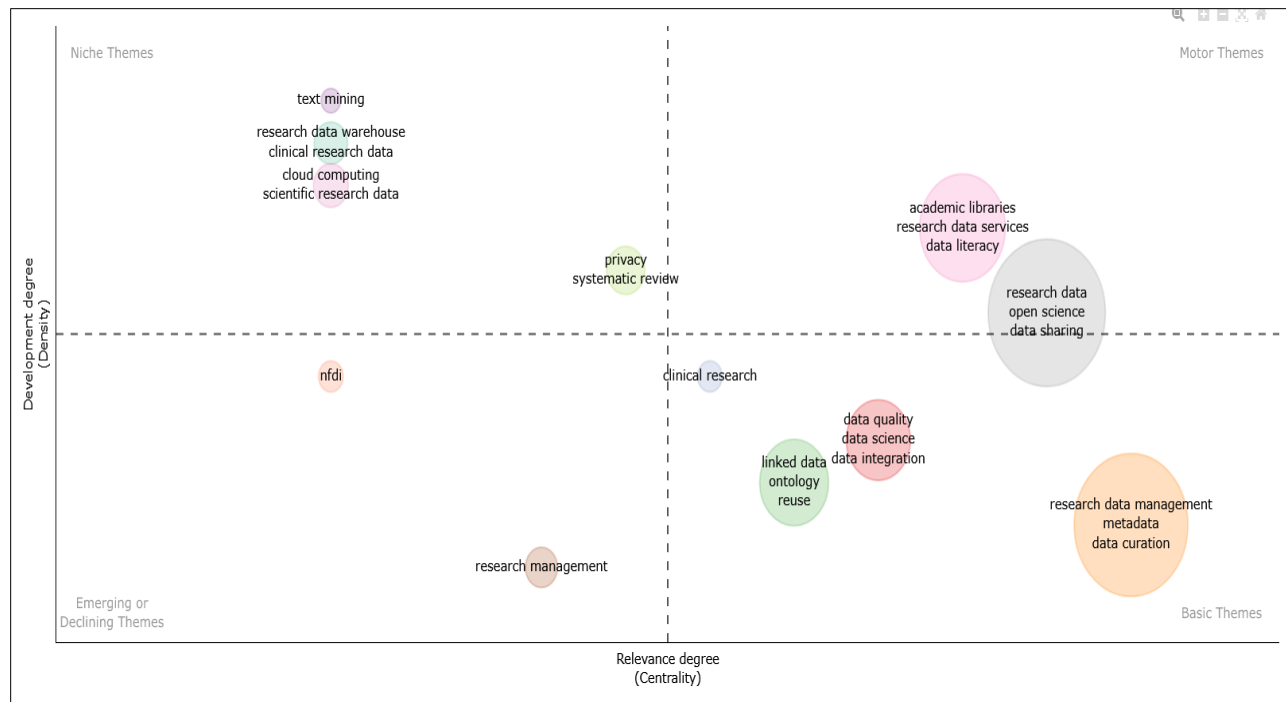


Figure 8 Thematic map analysis on RDM

Figure 7 shows the co-occurrence analysis (on author keywords) for the network visualization with a minimum number of keywords ($n=3$) of 3222 authors where 362 met the thresholds. In this analysis, 358 items, 21 clusters, 3083 links and 5743 total link strengths were found.

5.8 Thematic map analysis

This is a well-developed technique for data visualization and display the growth pattern. Figure 8 shows different themes of motor-niche-emerging-basic themes for thematic map analysis of research data management with relevance and degree of development. Author's keyword field, 200 number of words, with 5 minimum cluster frequencies are taken with Walktrap clustering algorithm to generate this map.

In terms of network analysis, there are four popular centrality measures - degree, betweenness, closeness and eigenvector. This study noted betweenness and closeness centrality values against the top ten keywords. Betweenness centrality measures the shortest path passing through nodes while closeness centrality measures the average shortest distance to all nodes. The table (Table 6) shows data with a maximum of 10 occurrence words with thematically aspects in RDM. Also in this table clusters, cluster labels and centralities were analyzed based on the most occurring terms with the rest of the fields. After setting all the parameters in the thematic map analysis, the number of words is 122 and up to 12 maximum clusters are retrieved where the top 10 words are tabulated based on maximum occurrence. As for this data, the term “research data management” tops the table with 521 occurrences.

Rank	Words	Occurrences	Cluster	Cluster Label	btw_centra lity	clos_cent rality	PageRank centrality
1	research data management	521	4	research data management	873.117	0.002	0.112
2	research data	411	7	research data	1,154.455	0.003	0.084
3	open science	117	7	research data	1,492.221	0.003	0.036
4	data sharing	107	7	research data	832.672	0.003	0.033
5	metadata	73	4	research data management	848.83	0.003	0.022
6	data management	72	7	research data	1,643.592	0.003	0.021
7	open data	71	7	research data	882.533	0.003	0.022
8	open access	69	7	research data	751.516	0.003	0.021
9	academic libraries	55	6	academic libraries	249.587	0.002	0.017
10	data curation	51	4	research data management	441.07	0.002	0.016

Table 6 Thematic map analysis with highest occurrences words on RDM

6. Discussion

This study analyzes research data management information very efficiently through various angles. A different analytical and graphical tool was used for a comprehensive view of RDM to meet the objectives of the study. High-level data searched by Scopus, the leading scholarly database, to provide sparse knowledge on research data management. This research shows results among 1273 filtered papers such as 535 sources, highest publication year 2022, top journal is “Data Science Journal”, top author is “C Ribeiro”, and various number of papers written by authors through Lotka’s law, most used keyword is “research data management”, collaboration of authors with Sankey diagram, co-occurrence network analysis and thematic map analysis. After all these discussions this study will help bring more attention towards research data management (RDM) in the academic area. RDM has many

applications in academic and research institutes including academic libraries (Xu, 2022). All methodological steps, data analysis and outcome outputs were systematically reviewed in this study.

7. Conclusion

This study systematically explored global research trends in Research Data Management (RDM) through a scientometric lens, revealing the field’s increasing academic significance and practical applications. The data-dependent society has now become more data-intensive for any kind of research work or other educational approaches. So, the progress of the whole research depends on the implication of data management in the right technical way. This paper clearly shows the initiation of research data management in various fields through different analytical tools. Therefore, the value of research data management is greatly increasing in most educational projects or research

projects to make raw data available for developing an authentic work. Based on findings of this study, it can be concluded that RDM is transitioning from a technical support, function to a central component of research infrastructure, driven by the demand for open science, data reuse, and transparency.

In summary, the research not only maps the current landscape of RDM scholarship but also offers actionable insights for researchers, data managers, and policymakers. In addition to understanding the value of research data management, here are some challenges to overcome. In daily life many information is searched by people worldwide which bring a new meaning to the society. Authentic information should be sharable to the general world so that further research works can be carried out smoothly and at the same time bring benefits for the development of the society. Now, that the right way of organizing data is more important than increasing the data, the process of ‘Research Data Management’ has proved its value and necessity for the society. The study’s major findings such as the growth of keywords like “data sharing”, co-occurrence trends, author productivity, and key thematic clusters indicate a shift towards the interdisciplinary and policy-driven research. This study will help future research by providing the highest level of evidence that helps organize data for proper use in research. In a word, nurturing RDM activities including training to the researchers increases the boundaries of the frontier of knowledge and thereby enhance the progress of the society.

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